Atti Soc. it. Sci. nat. Museo civ. Stor. nat. Milano, 137/1996 (I-II): 5-15, Settembre 1997

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Stomach contents of striped dolphins, *Stenella coeruleoalba* (Meyen, 1833), from the Western Ligurian Sea (Cetacea, Delphinidae) (***)

Abstract – The authors examined the stomach contents of 24 *Stenella coeruleoalba* stranded or incidentally caught in the Western Ligurian Sea. The remains of 1790 preys were found: 1027 bony fishes, 705 cephalopods and 58 crustaceans. Only one specimen had an empty stomach. Though the number of bony fishes is higher, cephalopods are the most significant prey in relation to distribution frequency.

Riassunto – Contenuti stomacali di stenella striata, *Stenella coeruleoalba* (Meyen, 1833), del Mar Ligure occidentale.

Gli autori hanno esaminato i contenuti stomacali di 24 stenelle spiaggiate o catturate accidentalmente nel Mar Ligure occidentale. Sono stati rinvenuti i resti di 1790 prede: 1027 teleostei, 705 cefalopodi e 58 crostacei. Solo un esemplare è risultato avere lo stomaco vuoto. Anche se i teleostei sono numericamente superiori, i cefalopodi sono le prede più significative in relazione alla frequenza di distribuzione.

Keywords: *Stenella coeruleoalba*, stomach content, Ligurian Sea.

Introduction

Stenella coeruleoalba (Meyen, 1833) is the dolphin most abundant in Italian seas, as demonstrated by the large number of strandings (Centro Studi Cetacei, 1987, 1988, 1989, 1990, 1991, 1992, 1993). Nevertheless its feeding biology has been analysed mainly in the extra-Mediterranean populations. In the Pacific (Japan waters), for example, more than half the prey was found to consist of bony fishes, the remainder being more or less equal parts of crustaceans and cephalopods (Miyazaki et al., 1973). All the species identified were pelagic or semi-pelagic and 74% was characterized by luminous organs. Analysis of one single specimen of striped dolphin caught off the coast of the Hawaiian Archipelago showed that 80% of the stomach contents consisted of cephalopods (Shomura & Hida, 1965).

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In the Western Mediterranean Sea the stomach contents analysed by Duguy et al. (1979) always consisted of cephalopods and, in part, of bony fishes, leading the authors to assume a more teuthophagous feeding than previously believed. Whereas Desportes (1985) reports a prevalence of bony fishes over cephalopods.

Two papers have recently been published on the feeding habits of striped dolphin in Italian waters. Bello (1992) analysed a specimen stranded on the Ionian shores: about 75% of the stomach content consisted of cephalopods. Wurtz and Marrale (1993) studied a higher number of specimens, all from the Ligurian Sea, in which bony fishes and cephalopods were found to have equal relative importance, even though the cephalopods have a higher occurrence while the bony fishes are dominant in number.

Since this work too concerns analysis of the stomach contents of striped dolphin from the Western Ligurian Sea, its results will add to our knowledge of the diet of these odontocetes.

Materials and methods

In this study we examined 24 striped dolphins, stranded on the West Ligurian shores or recovered already dead at sea. These operations were carried out for the Natural History Museum of Milan, in the context of the Centro Studi Cetacei (Società Italiana di Scienze Naturali), which coordinates the cetaceans national stranding network.

Table 1 shows the data concerning each specimen: date, place, Museum register number, total length and sex. Basic postmortem examination and tissue sampling were carried out; the skulls or complete skeletons have been preserved in collection of the Natural History Museum of Milan. Table 1 also shows the seven specimens whose death have been probably caused by pelagic drifting nets which, between 1988 and 1989, were responsible for a very high number of cetaceans by-catches in the Ligurian Sea (Centro Studi Cetacei, 1989 and 1990; Podestà & Magnaghi, 1989). In 1990, the great number of strandings on that short stretch of coast was ipothized to be linked to the striped dolphins die-off on the Spanish coasts (Aguilar & Raga, 1991), although the analysis gave negative result for a viral infection (Podestà et al., 1992). In specimen 6345 an abscess was found at the right cerebral hemisphere (Guarda et al., 1992).

During dissection of each specimen we separated the stomachs and drawed the content to recover even the smallest remains. The material was divided into systematic groups and preserved in 75% alcohol, except the otoliths of bony fishes which were dry-preserved.

We then identified each part to the lowest possible taxon. For determination of the Cephalopods we analysed the lower beaks, using Clarke's (1986) and Mangold & Fioroni's (1966) analytical keys, as well as comparison with samples of known species we extracted. The upper beaks were only counted, thus obtaining the highest reliable number of cephalopods present in each stomach. Bony fishes were determined on the basis of otoliths analysis as described by Harkonen (1986). In this case the presumed number of preys was obtained by considering half the total of each species found. Identification of other bony remains of teleosts was not possible. The descriptions reported by Alvarez (1968) were used for determination of the crustaceans.

On the basis of the results obtained we calculated the percentage of the three taxonomic prey categories (Cephalopods, Teleosts, Crustaceans) with regard to the total preys. For each of the three categories, we then calculated the percentage represented by each species with regard to the category total and the distribution frequency of each prey species: Fd=n/Ns (n is the number of stomachs containing the considered prey species and Ns is the number of stomachs containing residues of the relative systematic category).

Table 1 - Data concerning *S. coeruleoalba* examined. *: by-catches.

N° MSNMMa	Date	Place	LT cm	sex
4786	09/01/87	Ventimiglia (IM)	196.5	F
4894	15/07/87	Ventimiglia (IM)	183.5	M
6656	01/01/88	Noli (SV)	184	F
*4896	17/08/88	Western Ligurian Sea	191.5	M
*4898	04/10/88	Western Ligurian Sea	183.6	M
*4913	24/05/89	Ventimiglia (IM)	210	M
*6133	25/07/89	Giunchetto (IM)	201.5	F
*6147	25/07/89	Western Ligurian Sea	200	M
*6148	29/07/89	Western Ligurian Sea	210	M
*6149	06/09/89	Western Ligurian Sea	180	M
6134	13/06/90	Cervo (IM)	174.5	M
6341	14/08/90	Ventimiglia (IM)	174	M
6343	16/08/90	Imperia (IM)	187	M
6339	23/09/90	0spedaletti (IM)	187	M
6342	27/09/90	San Remo (IM)	173	M
6337	28/09/90	Giunchetto (IM)	189	M
6340	28/09/90	San Remo (IM)	205	M
6338	14/10/90	San Remo(IM)	182	F
6336	19/10/90	San Remo (IM)	184	M
6144	26/10/90	San Remo (IM)	193	M
6145	27/10/90	San Remo (IM)	176	M
6146	02/11/90	San Remo (IM)	183.5	F
6345	27/04/91	Bordighera (IM)	150	F
6344	31/07/91	Imperia (IM)	199	F

Results

Among the 24 examined striped dolphins, 23 presented food remains in their stomachs; only n. 6345 had empty stomach. The identified preys are listed in tables 2, 3, and 4.

Cephalopods were found in all 23 specimens (100%), while Teleosts remains were present only in 14 (60.9%) and Crustacean remains in 7 (30.4%). Considering the total number of preys (1790), however, bony fishes result the most numerous (Fig. 1).

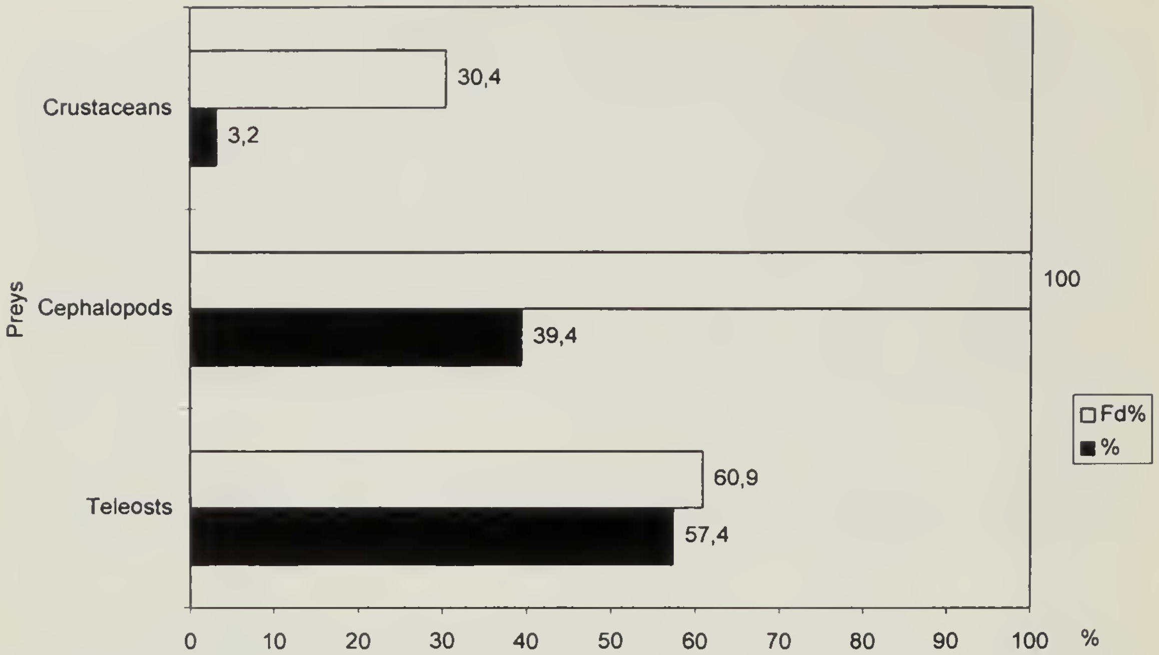

Fig. 1 - Percentage and distribution frequency (see text for explanation) of the preys found in the stomachs of *S. coeruleoalba*.

Table 2 - Cephalopods species and number found in the stomachs of *S. coeruleoalba*

	4786	4894	6656	4896	4898	4913	6133	6147	6148	614
Taxa of Cephalopods										
Sepiolidae										
Heteroteuthis dispar							6			
Sepiola sp.										
Sepietta oweniana										
Sepiolidae n.i.			1					12	4	
Enoploteuthidae										
Enoploteuthinae n.i.										12
Octopoteuthidae										
Onychoteuthidae										
Onychoteuthis banksii							1	2		7
Ancistroteuthis lichtensteinii		6		2	1	5		2	2	3
Onychoteuthidae n.i										
Histioteuthidae										
Histioteuthis bonnellii				26			8	1	8	
Histioteuthis reversa	3			3	35	3	3	3	9	3
Ommastrephidae										
Todarodes sagittatus		1	3	1		1	3	1	1	2
Todaropsis eblanae										
Ommastrephidae n.i.		3								
Cranchiidae						1				
Octopodidae										
Cephalopoda n.i.					5	1				30
Total taxa	1	3	2	4	2	4	5	6	5	5
Total lower	3	10	4	32	41	11	21	21	24	57
Total upper	1	10	4	26	38	9	4	34	31	60

Among Cephalopods (Table 2), 49 lower beaks out of 705 were not identified, being too decomposed and lacking the features useful for recognition. The total number of upper beaks was 602. The most numerous species was *Onychoteuthis banksii* (16%), while for distribution *Ancistroteuthis lichtensteinii*, *Histioteuthis reversa* and *Todarodes sagittatus* turned out to be the species with the highest frequency (Fd 56.5%) (Fig. 2). In specimens nn. 4896, 4898, 4913, 6133, 6147, 6148 and 6149 complete buccal masses were also found, together with the almost intact bodies of one *Todarodes sagittatus* and one *Ancistroteuthis lichtensteinii*. Specimen n. 6337 had both the highest number of different taxa and the highest number of beaks.

The bony fishes (Table 3) (found in 11 striped dolphins) totalled 1027, 154 of which indeterminable. The species with the highest distribution resulted *Boops boops* (Fd 72.7%); the most numerous were Myctophidae (57.4%) (Fig. 3). Striped dolphin n. 6134 had both the highest number of different taxa and the highest number of otoliths.

Crustacean remains were found in 7 striped dolphins (Table 4), but classification was possible only for a few of these (a total of 58). The most numerous species was *Pasiphaea multidentata* (55.2%). Striped dolphin n. 6133 turned out to have both the highest number of different taxa and the highest number of specimens.

beaks in each Striped dolphin														
6341	6343	6339	6342	6337	6340	6338	6336	6144	6145	6146	6344	Total	%	Fd %
												6	0.8	4.3
												48	6.8	4.3
												66	9.4	4.3
5	1			42						2		67	9.5	30.4
												12	1.7	4.3
		4										4	0.6	4.3
4	79			18	1					1		113	16.0	34.8
5	4			39				3	1	8		81	11.5	56.5
	6											6	0.8	4.3
1	31		2							7		84	11.9	34.8
3	2			11		1					5	84	11.9	56.5
2			1	1	1							41	5.8	56.5
											1	1	0.1	4.3
	3			17						5	4	32	4.5	21.8
				6								7	1	8.7
				4								4	0.6	4.3
	4			9								49	6.9	
6	7	1	2	8	2	1		1	1	5	3			
20	130	4	3	147	2	1	0	3	1	23	10	705	100	
15	114	7	4	154	1	2	3	4	0	19	5	602		

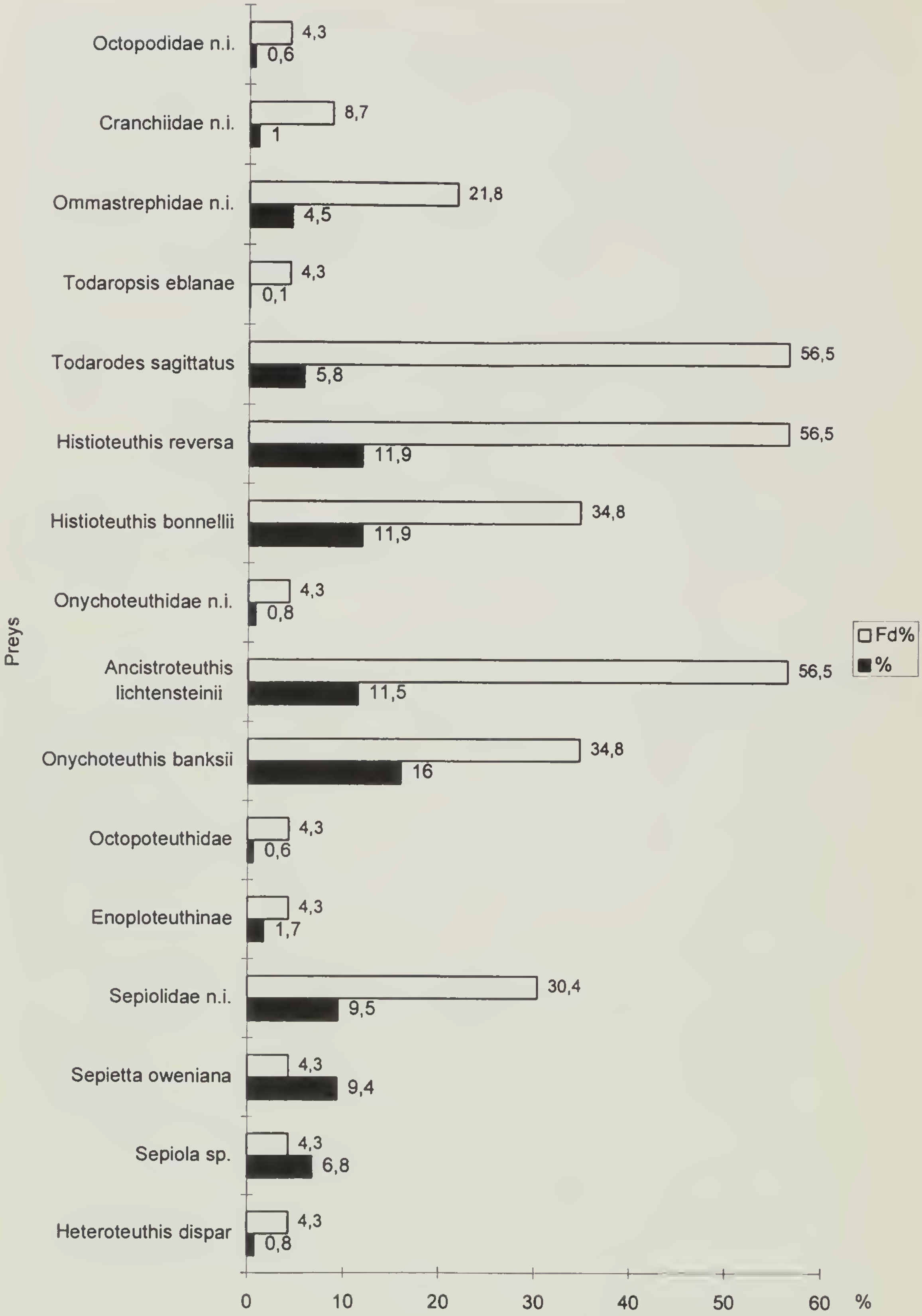

Fig. 2 - Percentage and distribution frequency (see text for explanation) of Cephalopods found in the stomachs of *S. coeruleoalba*.

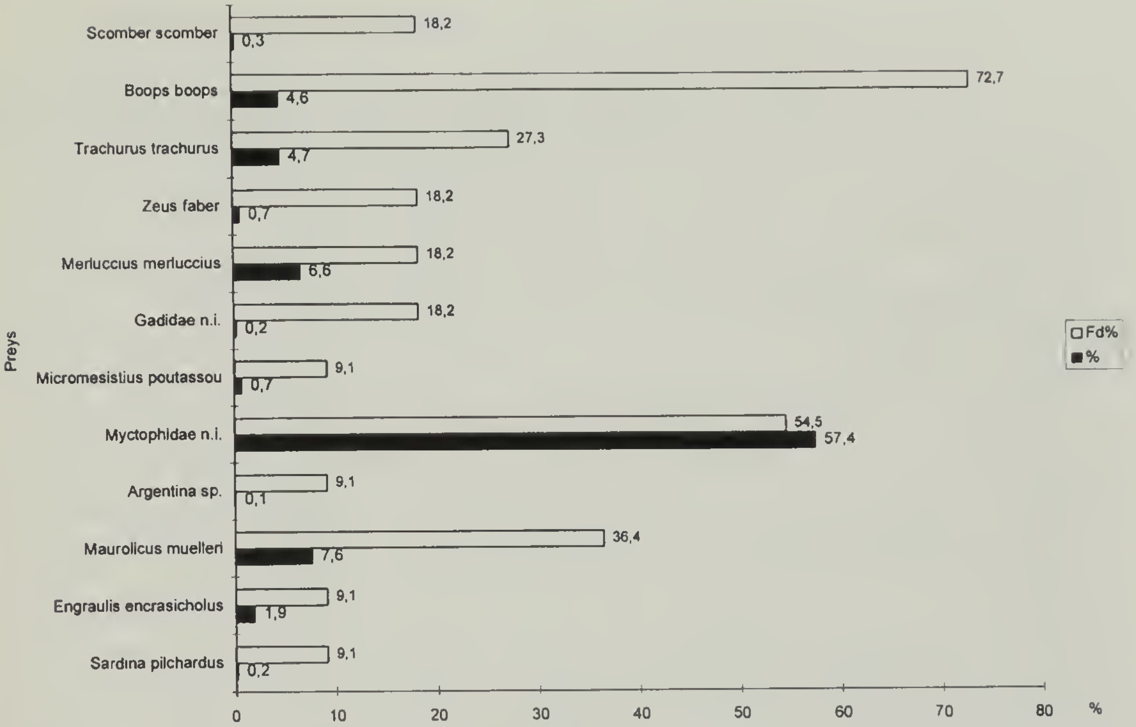

Fig. 3 - Percentage and distribution frequency (see text for explanation) of bony fishes found in the stomachs of *S. coeruleoalba*

Discussion

The results obtained by this study show a constant presence of cephalopods in the stomach contents examined: in all 23 striped dolphins with still recognizable remains, parts of cephalopod were in fact found. This is in agreement with previously published data on the Mediterranean specimens (Bello, 1992; Duguy et al., 1979; Wurtz et al., 1993). On the numerical basis, bony fishes were more abundant, similar to the result obtained by Wurtz and Marrale (1993). This would confirm the species' adaptability to a variety of preys, highlighting its feeding opportunism in function of the availability of food. The teutho-ichthyophagous definition of striped dolphin is also strengthened by the extra-Mediterranean results, where higher percentages of cephalopods or bony fishes alternate.

We should however remember that the amount of prey remains is affected by the different digestion times for the parts which are subsequently used for identification.

A significant sample is probably represented by those striped dolphins that were incidentally caught; almost complete bodies and buccal masses of cephalopods were found, as well as the still well preserved remains of crustaceans. It therefore seems probable that this is linked to a death very close in time to the last feeds, which are therefore well represented by non-digested preys. These striped dolphins always contained remains of all three taxonomic prey categories, which would further confirm the euryphagous feeding behaviour of this delphinid.

Most of the identified cephalopods (Onychoteuthidae, Histioteuthidae, Ommastrephidae and Cranchiidae) are pelagic. Others, for example some Sepiolidae and Octopodidae, are of benthic habitats (Roper et al., 1984). Also among bony fishes the identified species are mainly pelagic or meso-

Table 3 - Bony fishes species and number found in the stomachs of *S. coeruleoalba*

	4896	4898	4913	6133	6147	6148	6149
Taxa of Teleosts							
Clupeidae							
Sardina pilchardus							
Engraulidae							
Engraulis encrasicholus							
Sternoptychidae							
Maurolicus muelleri							
Argentinidae							
Argentina sp.							
Myctophidae n.i.					1	3	
Gadidae							
Micromesistius poutassou							
Gadidae n.i.			1				1
Merluccidae							
Merluccius merluccius							
Zeidi							
Zeus faber						5	
Carangidae							
Trachurus trachurus						6	
Sparidae							
Boops boops			2		4	5	
Scombridae							
Scomber scomber						1	
Otoliths n.i.					15	5	5
Total taxa			2		2	5	1
Total otoliths			3		20	25	6
Other parts bony fishes n.i.	+	+	+	+	+	+	+

pelagic, except *M. merluccius* and *B. boops*, which are considered demersal (Whitehead et al., 1986). The identified crustaceans are also pelagic or mesopelagic (Alvarez, 1968). But we know that almost all the above-mentioned preys undergo vertical migrations, and therefore it is not possible to determine the striped dolphin feeding depth range.

The presence in the same stomach of a high quantity of remains belonging to the same taxon (*O. banksii*, Myctophidae, *Pasiphea sp.*) suggests preying on species that form large shoals, which facilitates their capture by striped dolphin. This not homogeneous distribution of the preys found in the stomach could partly falsify the results. The highest number of otoliths identified, for example, belong to the Myctophidae family, but the greatest part was present in one single striped dolphin. This family was also found by Wurtz and Marrale (1993), as well as in extra-Mediterranean *Stenella coeruleoalba*, and therefore probably represents a typical prey of this dolphin. Whereas the species with the highest distribution frequency, *B. boops*, was found in very limited quantities in comparison with the number of Myctophidae.

The secondary predation should also be kept in mind: Sepiolidae, for otoliths in each Striped dolphin

4	6341	6343	6339	6337	6340	6336	Total	%	Fd %
							2	0.2	9.1
							20	1.9	9.1
	55				1	20	78	7.6	36.4
							1	0.1	9.1
5	3		5		13		590	57.4	54.5
							7	0.7	9.1
							2	0.2	18.2
						1	68	6.6	18.2
	2						7	0.7	18.2
						3	48	4.7	27.3
		2		2	4	2	47	4.6	72.7
							3	0.3	18.2
	2		71	12	11	1	154	15	
	3	1	1	1	3	4			
3	62	2	76	14	29	27	1027	100	
	+	+				+			

example, were always found together with the remains of *T. sagittatus* or other Ommastrephidae. Since *T. sagittatus* feeds on *H. dispar* (Bello, 1990), it is possible that the remains of the latter species constitute the residues of secondary predation. This would also be borne out by the fact that only Sepiolidae beaks, but much less digested Ommastrephidae parts, were found. Also in the case of bony fishes it is likely that a secondary predation phenomenon occurred, for example *M. poutassou* on *M. muelleri*, *M. merluccius* on *E. encrasicholus* and *S. pilchardus* (Whitehead, 1986).

Acknowledgments - We would like to give our warmest thanks to Drs. G. Bello, G.B. Grippa, C. Froglia, P. Gaemers and M. Wurtz, who supplied precious help in determining the parts found. We also thank all our friends and colleagues who worked with us on recoveries and dissections, and in particular: E. Bianchi, C. Benoldi, V. Fogato, P.F. Gavagnin, L. Magnaghi, M.T. Manfredi, W. Mignone, B. Nebuloni, S. Palmero, G. Rattegni, G. Repetto and A. Zaniboni. Thanks also to Dr. S. Scali for graphic data processing and to Dr. L. Cagnolaro for his helpful advice.

Table 4 - Crustaceans species and number found in the stomachs of *S. coeruleoalba*.

	N° of specimens of Crustaceans in each Striped dolphin								
	4896	4898	4913	6133	6147	6148	6149	Total	%
Taxa of Crustaceans									
Pasiphaeidae									
Pasiphaea sivado					10			10	17.2
Pasiphaea multidentata				32				32	55.2
Penaeidae									
Funchalia woodwardi				3				3	5.2
Oplophoridae									
Acantephira pelagica				5				5	8.6
Sergestidae									
Sergestes sp.				8				8	13.8
Crustacea n.i.	+	+	+			+	+		
Total taxa				4	1				
Total individual				48	10			58	100

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